AGROFORESTRY IN THE WORLD: LESSONS FOR CANADA

Andrew M. Gordon and colleagues

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While their potential for contributing to the economic diversification of Western agriculture remains largely untapped, agroforestry practices are well ensconced in several temperate regions around the globe. But in Canada, their rate of adoption remains low. To Andrew M. Gordon and his colleagues, the biological, physical and chemical interactions introduced through agroforestry systems are crucial for improving the quality of the environment for future generations of Canadians. They review common agroforestry practices in China, Europe, Argentina, Australia and New Zealand, and discuss the socio-economic implications for Canadian agriculture of adopting these practices. Agroforestry, they maintain, has considerable potential to resolve many current concerns about the viability of rural agricultural communities.

Bien que leur contribution à la diversification économique de l'agriculture occidentale reste largement inexploitée, les pratiques agroforestières sont bien ancrées dans plusieurs régions tempérées du globe, alors qu'au Canada on ne les adopte que très lentement. Pour Andrew M. Gordon et ses collègues, les interactions biologiques, physiques et chimiques propres aux systèmes agroforestiers sont pourtant indispensables à la qualité de l'environnement que nous léguerons aux futures générations. Ils examinent ici les pratiques agroforestières de la Chine, de l'Europe, de l'Argentine, de l'Australie et de la Nouvelle-Zélande et évaluent les incidences socio-économiques qu'elles pourraient avoir sur l'agriculture canadienne. L'agroforesterie, soutiennent-ils, est toute désignée pour surmonter les craintes actuelles concernant la viabilité des communautés agricoles du pays.

Over the last few decades, agroforestry has emerged from long historical roots to become a recognized modern land use practice in some parts of the world. Modern agroforestry has its roots in developing countries, where the high demand for land to produce both food and fuel led to the development of small-scale, yet complex, production systems. In these countries, agroforestry helps to alleviate poverty, increase nutritional security and arrest land degradation. In contrast, in industrialized nations, its primary role is to provide ecosystem services.

Agroforestry is the growing of trees and/or other perennial plants together with annual crops and/or animals on the same piece of land (see box 1). Its ecological and economic returns depend on the positive interactions between the individual components of these systems, along spatial and temporal scales. It relies on the premise that plant communities that are more complex than monocultures will capture nutrient, light and water resources more efficiently. Enhanced plant diversity results in "niche complementarity" (i.e., the use of different resources), as well as spatial and temporal partitioning of resource use by the different plant species. Enhanced plant diversity may also improve the stability and resilience of the crops and provide habitat connectivity for birds and mammals. This is critically important in fragmented agricultural landscapes. The ecological foundation of agrofrestry manifests itself in a variety of environmental services such as the sequestration of carbon, the conservation of biodiversity and the enhancement of water quality.

While their potential for contributing to the economic diversification of Western agriculture remains largely untapped, agroforestry practices are well ensconced in several temperate regions around the globe. In contrast, their rate of adoption remains low in Canada. An examination of the biological, physical and chemical interactions found in agroforestry systems, to the extent that has been achieved in other food production systems, seems therefore crucial for improving the quality of the environment for future generations of Canadians. We will first review some common agroforestry practices in China, Europe, Argentina, Australia and New Zealand, and then we will discuss some of the socio-economic implications for Canadian agriculture of adopting these practices.

China is the historical seat of many agroforestry practices, and they have been part of Chinese farming for centuries. As adopted in temperate regions of this country, they play an important role in modifying microclimate conditions, preventing soil erosion and desertification and increasing agricultural productivity and resource supplies for basic family needs.

The adoption of agroforestry in China is relatively high because of historical familiarity, and the farming community also benefits from highly organized extension programs tightly linked to research units. But a lack of marketing knowledge among farmers limits its widespread development. For example, in the 1980s, paulownia-winter-wheat intercropping systems that showed much promise — were established over 2 million hectares. However, the domestic market for paulownia timber was insufficient, and many farmers were reluctant to replant new paulownia crop systems. Investment in industries that require wood (e.g., furniture) is, therefore, critical to the continued refinement of the many unique agrofrorestry systems in China.

Although forest farming does not necessarily embrace the gathering of native plants from forest understories, this too can be a source of external revenue. As a recent example, demand for wild Canada yew is expected to increase at a rate of about 10 percent per year for the foreseeable future, largely because this plant is a source of paclitaxel, an active anti-cancer chemical that enjoyed US$4.2 billion in sales worldwide in 2003.

BOX 1. TYPES OF AGROFORESTRY PRACTICES

In North America, the Association for Temperate Agroforestry recognizes five types of agroforestry practices:

- Alley-cropping — trees and agricultural crops are grown in alternate rows
- Windbreaks and shelterbelts — trees are planted around the perimeters of agricultural fields
- Forest farming – forested areas are used for producing medicinal, culinary, ornamental or other products
- Silvopasture — trees are grown in combination with livestock production
- Riparian buffer strips — perennial vegetation is established on the banks of bodies of water in agricultural areas

As a whole, the Chinese experience in agroforestry research and development is extremely relevant to other developing countries, and will be more so as the domestic demand for its products and services increases.

Agroforestry practices have also been present in Europe for centuries, but there is little coordinated research or accounting of these systems. But in the early 1990s, the Agroforestry Research Program was launched, and it has given considerable impetus to several countries adopting a unified approach.

In 2001, the EEC funded a four-year research program, Silvoarable Agroforestry for Europe (SAFE), in order to reduce the uncertainties concerning the validity of silvoarable systems, to extrapolate plot-scale results to different regions and to suggest unified European policy guidelines. As a result, article 44 of the recent European Charter promotes incentives for continued development of agroforestry in Europe. The drivers for its development in other countries (e.g., land sustainability, maximized production, etc.) are, however, largely absent in Europe. Much of Europe is still forested (about 37 percent), and the forest area is increasing as many marginal agricultural lands have been abandoned. Therefore there is little driving need for the wise incorporation of trees into farming systems, and the receptivity of the farming community to agroforestry practices is higher in countries with little forest cover.

Nonetheless, Europe remains a major importer of high-quality hardwoods, and this demand has driven the development of hardwood production on agricultural lands, either as plantations or in agroforestry configurations. Its key role in Europe may actually be, therefore, in helping to resolve land use conflicts that have come about as traditional agricultural land has been taken over by non-farming landowners, who are more likely to see timber tree production as a long-term investment. The farming community, fearing the loss of additional agricultural land, may in the end become receptive to agroforestry as the best compromise.

Another case, this time with large environmental spillovers, was Argentina in the late 1800s. As a result of rapidly expanding agricultural activities, livestock production was pushed into marginal areas, such as Patagonia, in the extreme south of the country. Severe overstocking combined with a fragile environment led to major land degradation, and severe desertification was noticed as early as 1910. Subsequently, a variety of silvopastoral systems have been utilized to reverse land degradation, at the same time allowing animal production to proceed.

These systems can be described as follows: (1) nomadic sheep and cattle grazing in arid steppes at 500 to 700 metres elevation in cold weather, and in public forests and meadows at 900 to 1,300 metres during summer; (2) year-round grazing in meadows and steppes with occasional browsing in forests; and (3) seasonal grazing of lowland forests or the forest-steppe ecotone during winter, and highland forest grazing in summer.

Desertification continues in parts of Patagonia, and this, coupled with current low wool prices and other complex socio-economic problems, is contributing to the livestock production crisis. The continued development of silvopastoral systems, in concert with continued wood production in both native and exotic forests, appears to be an economically sound diversification strategy with numerous associated ecological benefits.

More recently, in the 1980s, agroforestry has flourished in certain regions of Australia to protect soils and water from further degradation. Much has been learned, in areas receiving greater than 600 millimetres of annual rainfall, about species suitability, establishment techniques and configurations, and tending practices. Early plantings have matured into excellent demonstration areas. There is currently a national demand for wood and wood products, and hence for "trees on farms." This is driving the development of new industries based on farm-grown tree products. As an example, in the 1990s a new pulp industry was developed in the southwest of Australia, which drove the development of integrated plantings of blue gum (*Eucalyptus globulus*). By 2010, it is estimated that 5 million tonnes of blue gum will be available annually from local farmers. The diversification of farm income by wood production through agroforestry practices contributes positively to the long-term and sustained prosperity of both farmers and the nation.

In the early 1990s, severe structural changes in the New Zealand economy had largely beneficial effects on agroforestry. Agricultural subsidies were abolished, taxation became neutral across many land uses, state forests were privatized and domestic and international log markets flourished. These were all positive incentives for farmers looking for additional farm income.

A popular system researched and developed in New Zealand is the practice of integrating sheep production in a silvopastoral fashion with radiata pine. The latter are planted at a density of 250 stems per hectare and pruned to at least 6 metres for added value as veneer. Grazing is available for at least the first 8 to 10 years of an anticipated 25-year tree rotation. In the next 20 years, over 1 million hectares of former farmland may end up in this configuration, with added attention to the development of shelterbelts. Animal welfare is an emerging issue here and elsewhere, and silvopastoral systems may find a niche market with respect to this concern.

There is considerable current concern about the viability of Canada's rural agricultural communities, and their ability to survive and flourish within the context of large, corporate farming initiatives and land acquisition by urban dwellers. Agroforestry systems, because they embrace long-lived, valuable, perennial tree species, are uniquely positioned to address some of these concerns.

In Quebec and Ontario, trees from various genera (*Acer, Betula, Fagus, Fraxinus, Juglans, Prunus* and *Quercus*) are well adapted for use in many agroforestry systems, and species from these genera are often highly valued for their lumber and other products (e.g., maple syrup). One of the disjuncts of farming is that subsequent generations of youth are less than enthusiastic about continuing on the family farm, as a result of the high debt load they need to incur in order to buy out other family members at retirement time. An agroforestry system, established well on in the rotational cycle of the family farm and managed for quality products, could ease the transitional burdens of young family members, since the agroforestry crop could be liquidated at the time of farm transfer, substantially lowering borrowing costs.

The adoption of such systems will often provide additional revenue streams for both agricultural producers and woodlot owners. For the latter, it is possible to extract a plethora of existing and exciting new products from hardwood woodlots by adopting forest farming practices, which include the management and cultivation of aromatic, edible or artistic specialty crops. Although maple syrup is the predominant forest farming crop, some other examples of potential crops that could be cultivated within hardwood woodlots include ginseng, shiitake mushrooms, honey, nuts from various tree species (e.g., walnuts), baskets (made from ash trees), and clothing (birchbark vests, dresses, etc.). Of the 422,000 plant species documented around the world, about 12.5 percent are known to have medicinal value, although only a few are in cultivation.

Although forest farming does not necessarily embrace the gathering of native plants from forest understories, this too can be a source of external revenue. As a recent example, demand for wild Canada yew is expected to increase at a rate of about 10 percent per year for the foreseeable future, largely because this plant is a source of paclitaxel, an active anti-cancer chemical that enjoyed US$4.2 billion in sales worldwide in 2003. Commercial harvesting of yew began in Ontario in that year, and by 2005 almost 400,000 kilograms was harvested in the province, principally from the Crown forest.

Integrating trees into pasture land in the form of a silvopastoral system offers many economic challenges and benefits, including a constant flow of marketable products while at the same time maintaining long-term site productivity. The net present value per unit area and internal rates of return are often substantially higher for silvopastoral operations than they are for sole animal or sole forestry operations. For integrated riparian management systems, strong economic gains can be had through careful extraction of wood and other products from riparian areas, and there are also non-market benefits such as improved water quality and carbon sequestration for improved global climate.

Alley-cropping systems can also offer excellent returns. Using a net present value approach, researchers in Ontario compared the economics of an intercropping system with that of conventional agriculture, and they concluded that intercropping systems were profitable when interest rates were low (< 5 percent), or if annual tree products such as marketable nuts

Courtesy of David Rivest

Silvopastoral systems, in which trees are grown in combination with livestock, have been adopted in several countries across the world, in Argentina and New Zealand, notably. Here an example of such system in France, where sheep graze under common walnut trees.

or syrup were factored into the economic models. Additional income would be generated if environmental benefits such as carbon sequestration were acknowledged and assessed.

Despite the potential economic and environmental benefits associated with agroforestry systems, their adoption rate remains low in Canada. This is not true for all types: traditional systems such as forest farming (e.g., maple syrup), the establishment of windbreaks and the planting of trees along the banks of agricultural streams are relatively common. However, more unique systems, such as intercropping and silvopasture systems, remain scarce, despite well-documented research into the installation and operation of these systems in a temperate environment.

The University of Guelph regularly organizes tours for interested groups, including farm associations. This interaction between researchers and farm operators fosters good discourse, helping the farm community understand how agroforestry systems can be adopted and honing pertinent research questions for the researcher. An increase in the adoption rate has been noted as a result of such interactions. Research indicates there has been a shift in the farm community's view of agroforestry systems away from a solely economic perspective toward one that embraces a stewardship ethic. Ironically, the fact that some farmers have chosen to adopt a sustainable, integrated agroforestry system over a high-input monocropping system demonstrates their concern for protecting and conserving the environment while still profiting from marginal lands.

The suite of agroforestry systems available to Canadian landowners presents numerous economic diversification strategies, useful in an increasingly complex commodities mix. Certain systems, such as bioenergy from short-rotation willow and/or poplar, have great potential for the future, especially given their ability to provide clean, carbon-neutral energy. As economic inputs in woody bioenergy systems are substantially less than those involved in corn systems used for ethanol production, the demand for such systems should only increase.

In our view, agroforestry offers long-term rural landscape sustainability and provides economic resilience through income diversification to the Canadian family farm.

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